



Genencor International®
Innovative by Nature®

THE BIOBASED ECONOMY

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WI Bio-based Industry Consortium

www.genencor.com

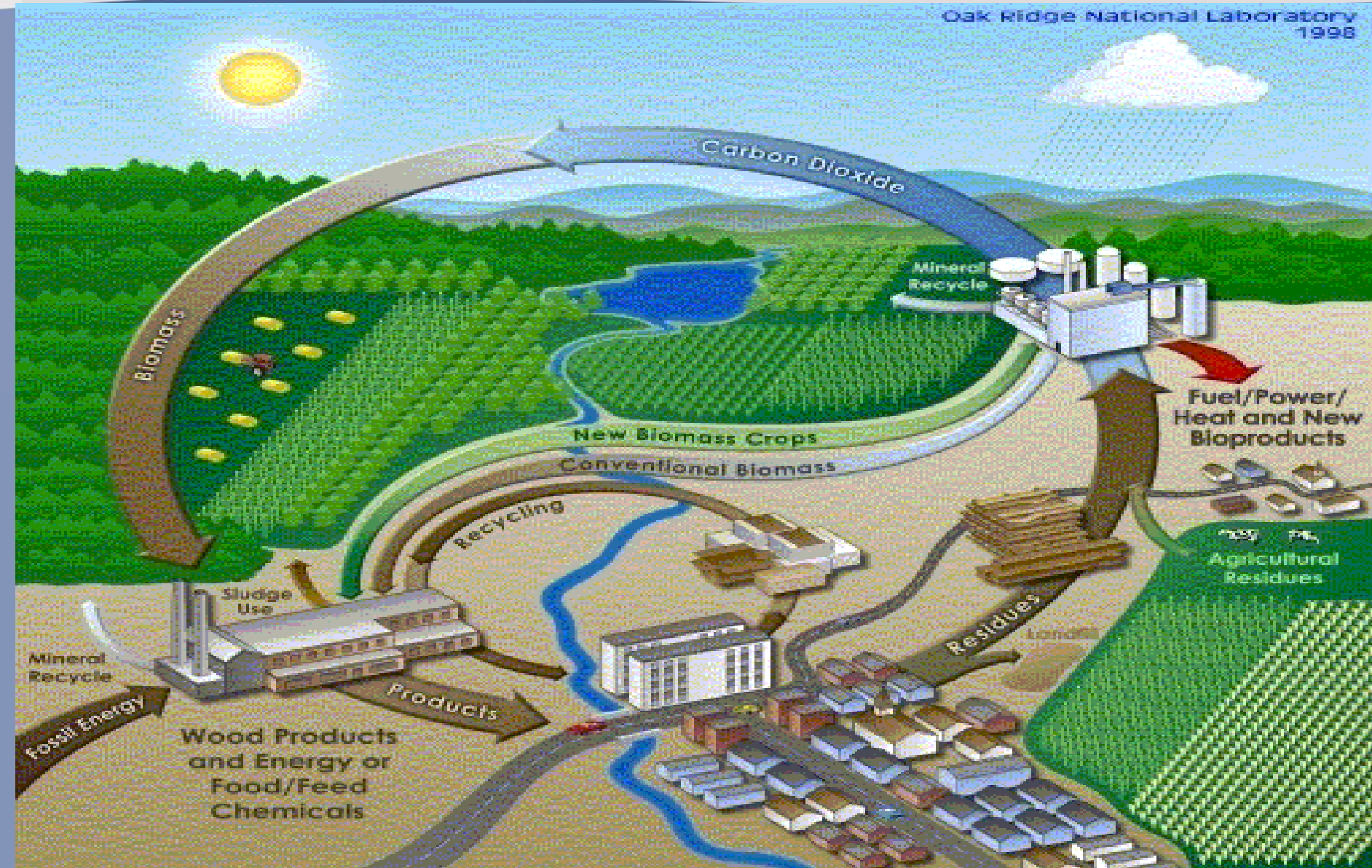
- Define the Bio-Based Economy
- State of the Industry
- Benefits of a Bio-Based Economy
- Current and Future of Bio-Based Products
- One Key Focal Points (Bio-Energy)



An economy based on
biotechnology that uses
RENEWABLE RAW MATERIALS
to produce products and
energy.

Threshold of a New Era: Biorefinery

Oak Ridge National Laboratory
1998



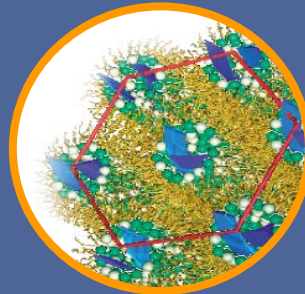
The Genencor Biorefinery



Biofuels



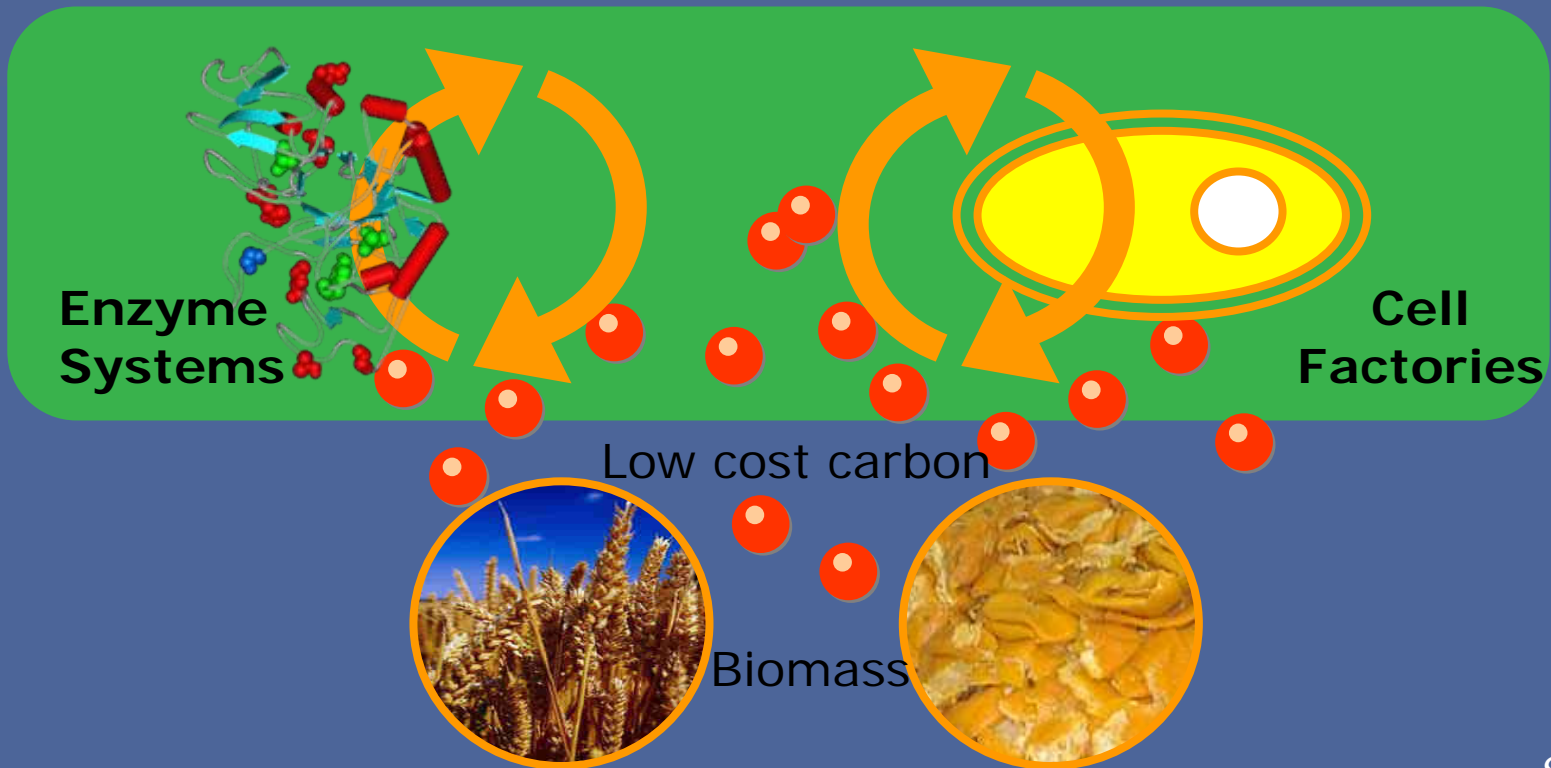
Biochemicals



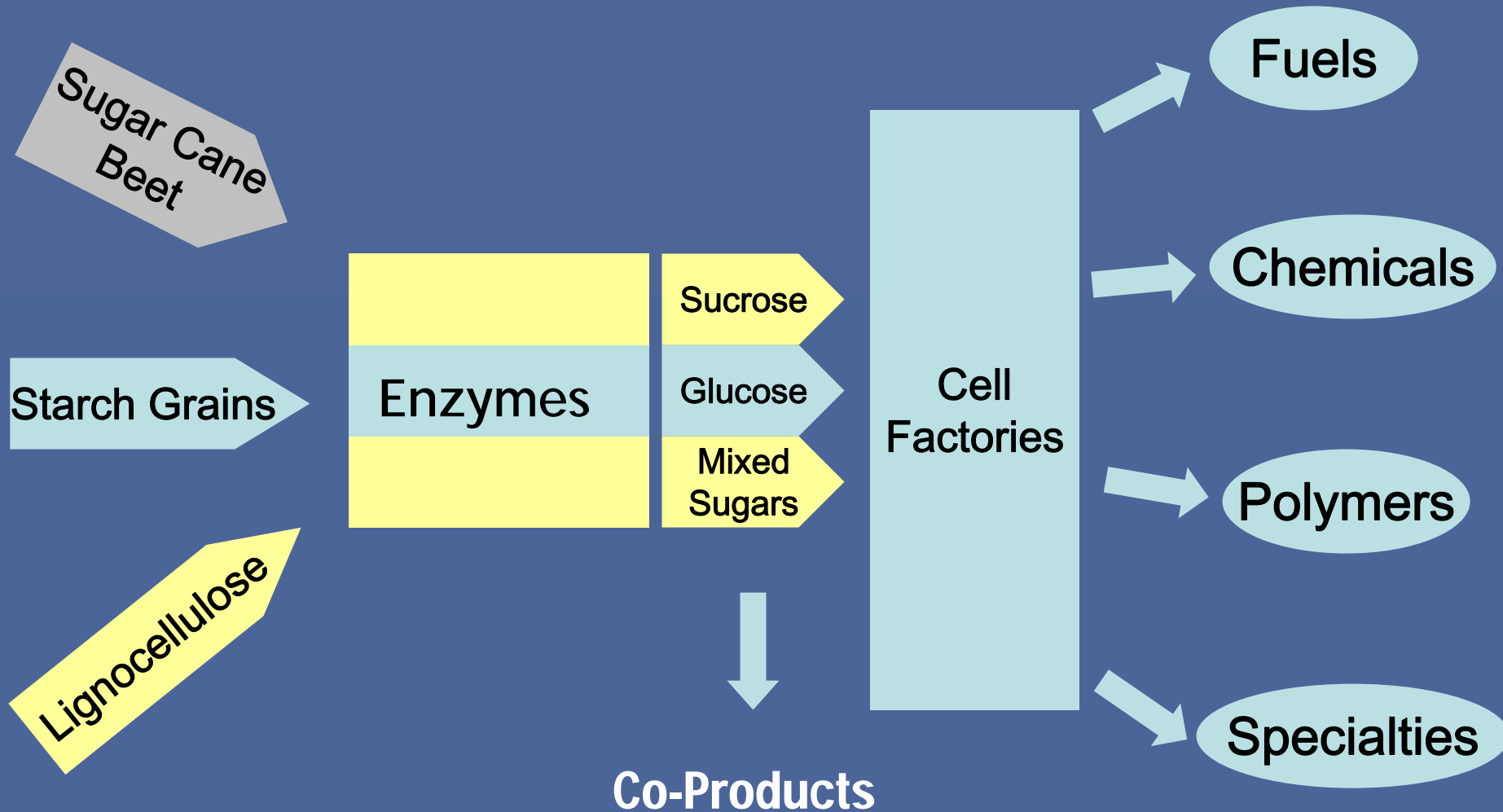
Biomaterials



Bioactives



The Bio-Refinery Concept



What is Driving the Penetration of Industrial Biotechnology?

- **Significant pollution prevention** – Industries spends billions on technology to manage waste and capture polluting effluents and emissions. Industrial Biotech can prevent much of the the pollution from occurring in the first place.
- **Cost savings** – Few process steps means lower capital and operating costs.
- **Lower consumption of energy** – A significant amount of energy in chemical synthesis is saved by replacing the number of chemical steps with fewer steps at lower temperatures
- **Reduced use of nonrenewable feedstocks** – Oil vs. corn or biomass – *“Enough agricultural crop waste is produced each year to entirely replace the 700 million barrels of oil used in organic chemical production”**
- **Unpredictable oil prices** – Adding significant uncertainty to cost of goods.

* Source: “New Biotech Tools for a Cleaner Environment” , Biotechnology Industry Organization, 2004

An Example:

1. Glucose
2. K-Arabonate
3. Ca-Arabonate
4. Ca-Rionate reagent
5. Riobolactone reagent
6. Ribose reagent
7. Ribitylxylidine(RX) reagent
8. Phenylazo-RX
9. Vitamin B-2

1. Vegetable oil feedstock
2. Fermentation with GMO



3. Vitamin B-2

Benefits:

- Reduced carbon dioxide emissions by 80%
- Reduced water emissions by 67%
- Reduced cost by 50%
- In five years, fermentation went from 0% to 90% world market share for B-2

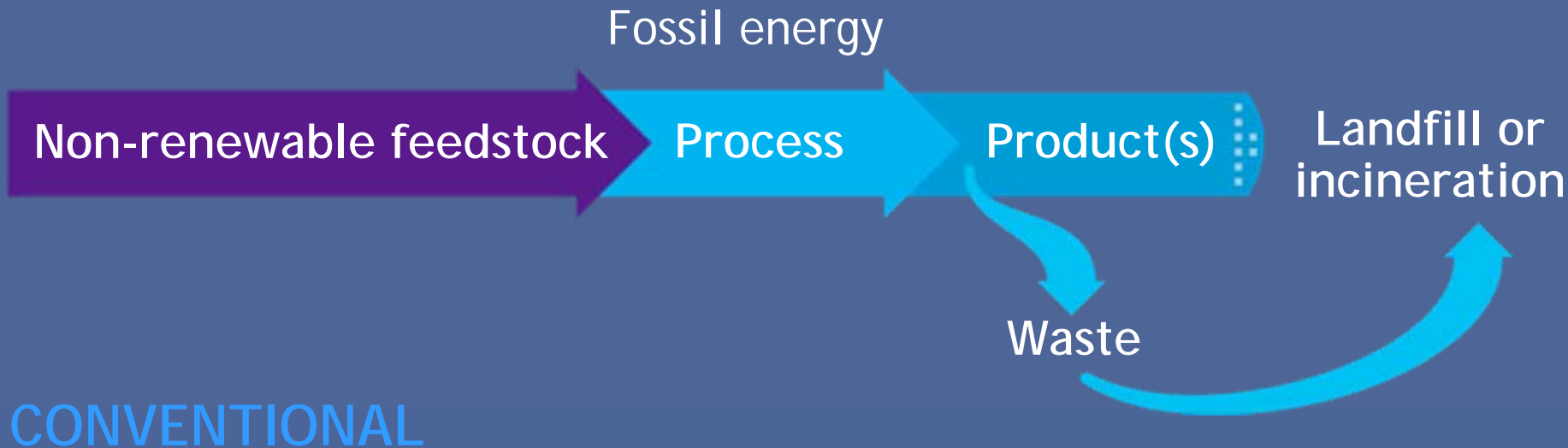
What are the Barriers to Transformation?

- **Fear comes from ignorance** - Must counteract anti-bio movement by continuing to educate consumers. Some progress since “white” biotech has a positive image.
- **Eyes glaze over** - Chemical company directors and senior management need to understand how it will help their companies grow profitably. Reduce focus on technology, focus on business.
- **Not now but maybe in 25 years** - Need to make aware that the technology is available for deployment NOW.
- **Environmental awareness** - Public environmental officials “seem only vaguely aware” of the ability of biotechnology to “green” the industrial landscaped.

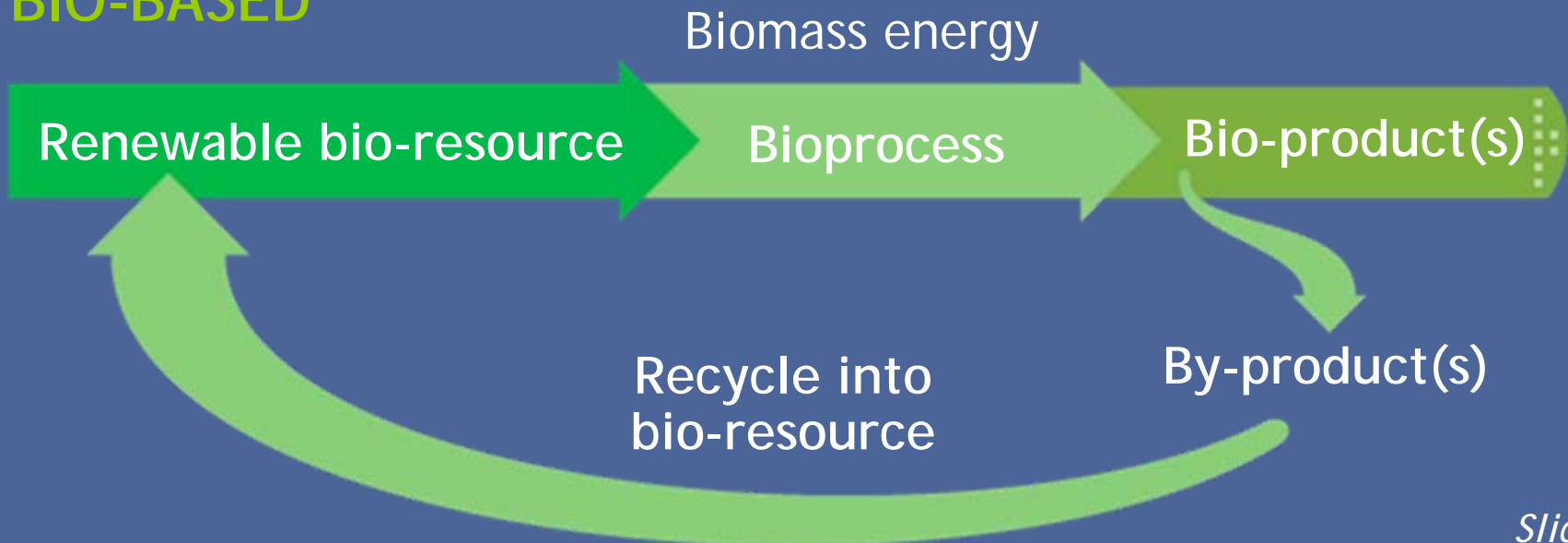
Obvious Need for Sustainable Solutions



Benefits of the Biobased Economy



BIO-BASED



Economic

- Reduce cost, better control of product properties
- New product & market opportunities
- Improved balance of trade & energy independence

Environmental

- Pollution prevention, reduced emissions of GHG and toxics
- 'Green' fuels, chemicals & materials
- Reusable & recyclable products

Social

- Rural economic diversification & growth
- Developing countries can access the biobased economy
- Improvements in human/environmental health & quality of life



Use of Biotechnology Everyday

- Textiles
- Starch Processing
- Fuel Ethanol
- Brewing
- Leather
- Baking
- Pulp and Paper
- Food and Beverages

Innovative Products for MANY Industries

Biomaterials

Chemicals

Nutrition



Biopharmaceuticals



Personal Care

Aromatics



Bio-Energy & Bio-Fuels



**Food and
Flavors**

Bio-safety & Bio-defense

Sorona®

Polymer of the Futurefrom Corn

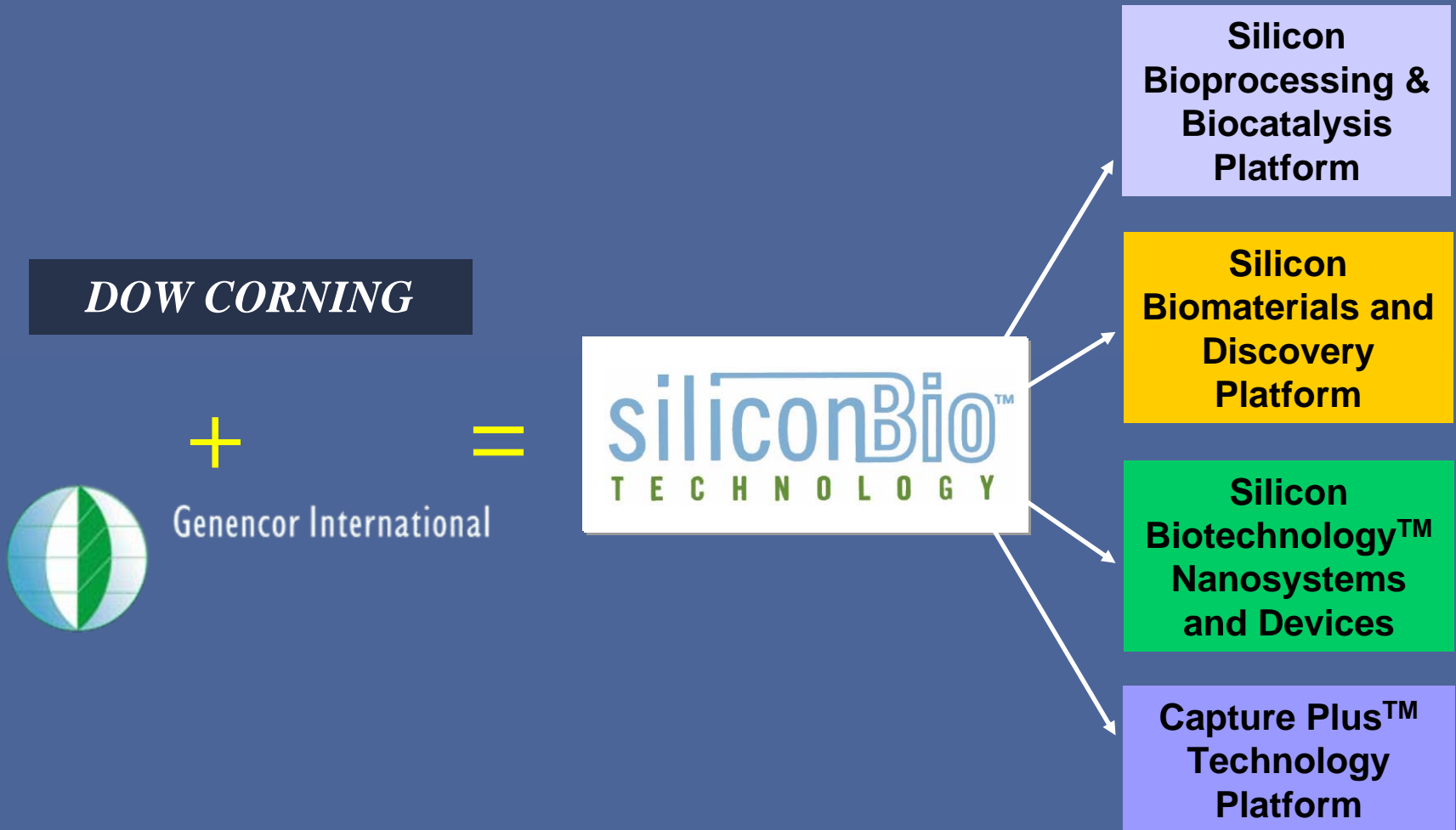
Sorona® 3GT polymer

- Genencor's DesignPath™
Pathway to create Cell
Factory to produce new
biobased polymer



The miracles of science™

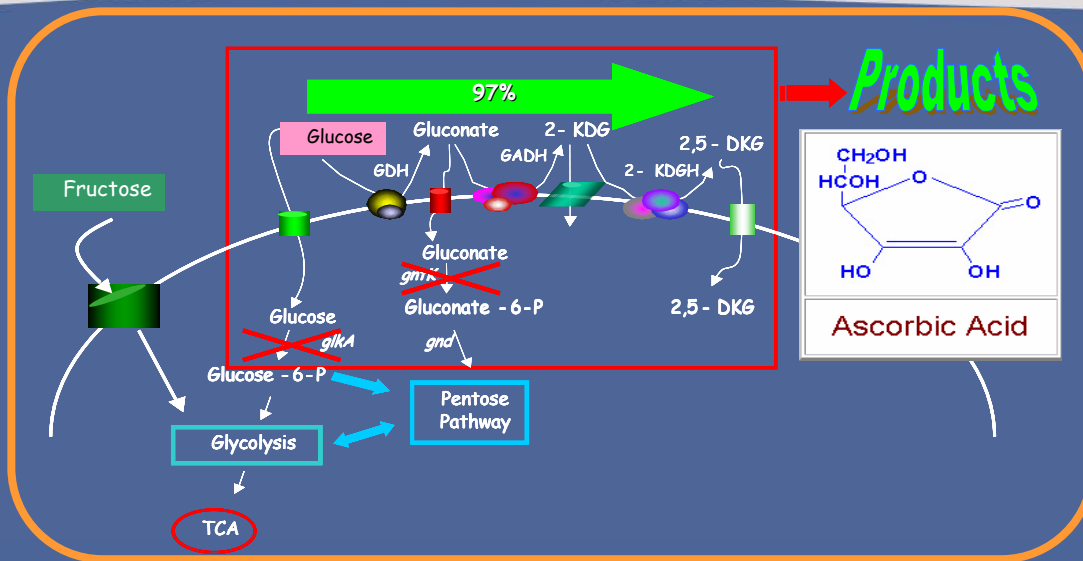
Merging Technologies - Silicon Biotechnology™



- GenenCare™ Performance Ingredients
 - Teeth cleaning and whitening
 - Skin pigmentation
 - Hair care

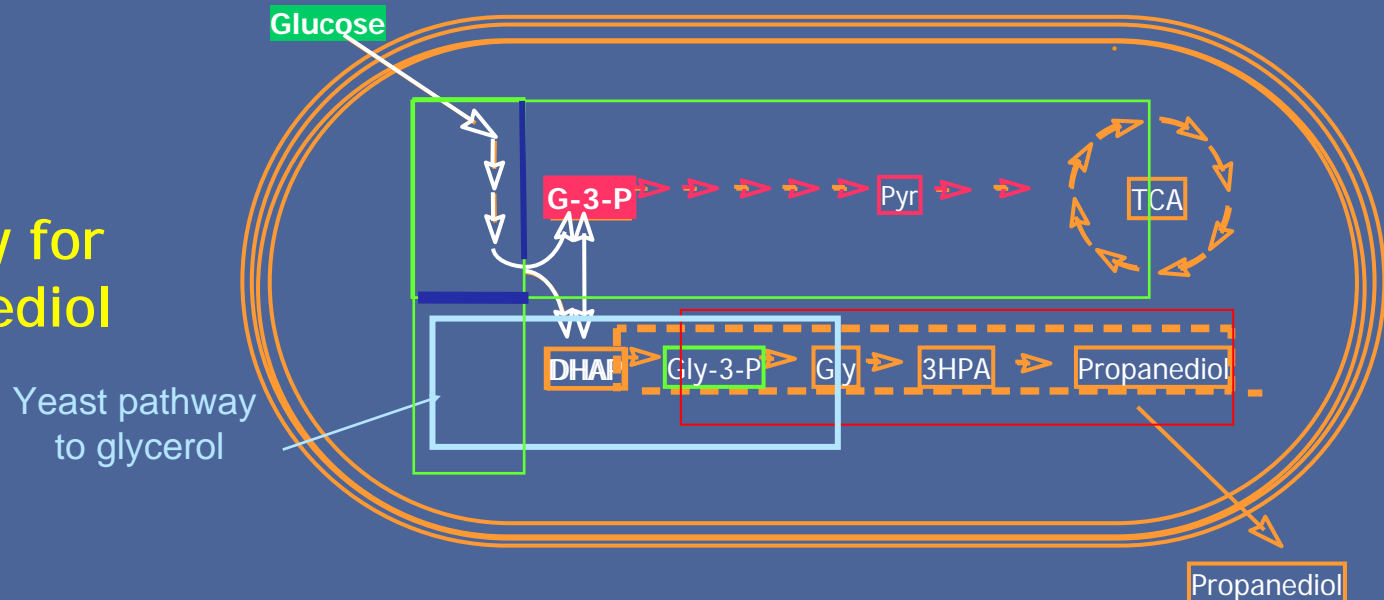


"Cell Factories" Customized by DesignPath™



Cell Factory for Ascorbic Acid

Cell Factory for 1,3 Propanediol



- Ethanol from corn
- Ethanol from biomass



Ethanol Production Growth in the U.S.

- In 2004, 81 plants in 20 states produced 3.41 billion gallons, up 21% over 2003 and 109% since 2000
- At the end of 2004, 16 plants and 2 major expansions were under construction, representing an additional 750 million gallons of production capacity
- In 2004, the corn ethanol industry processed a record 1.26 billion bushels of corn =11% of the U.S. corn crop*



* Renewable Fuels Association

- Added \$25.1 billion to gross output
- Supported the creation of 147,000 jobs throughout the economy
- Boosted U.S. household income by \$4.4 billion through increased economic activity and jobs
- Added \$1.3 billion of tax revenue to Federal government and \$1.2 billion to state and local governments

2004

- Ethanol use reduced CO₂ equivalent emissions by approximately 7 million tons

= annual emissions of
1 million cars from the road

Biobased Future

- Reduced CO₂ equivalent emissions by approximately 1.7 billion tons
- roughly 80% of transportation-related emissions
- and, 22% of total USA emissions in 2002



"Growing Energy: How Biofuels Can Help End America's Oil Dependence," December 2004.

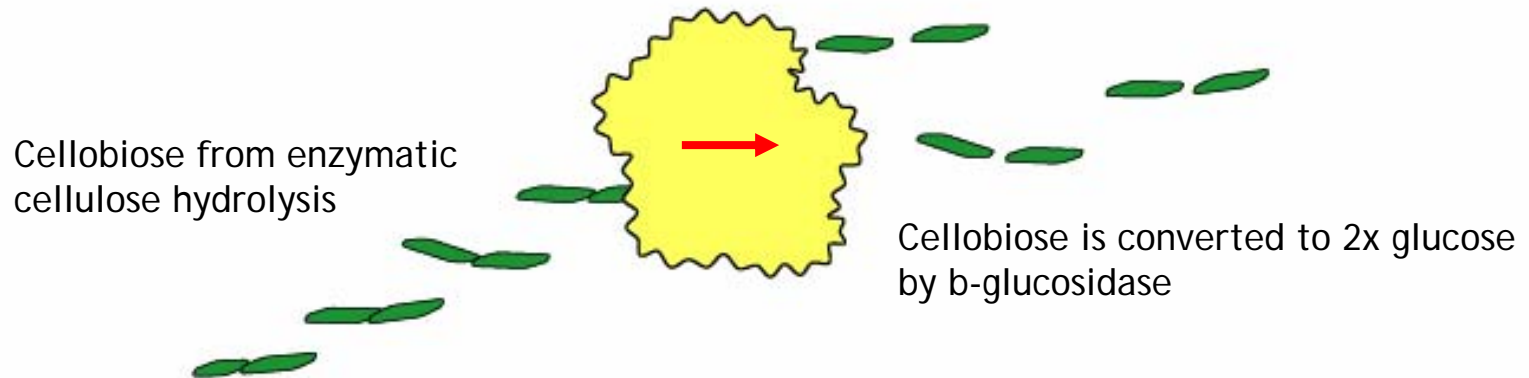
- Reduction of oil demand by 2/3
- By 2015, biofuels could add 7.9 million barrels/day
- In advanced biorefineries (co-production of fuel & power) each ton of biomass displaces
 - 2 barrels of crude oil
 - 1.28 tons of GHG emissions

Biomass is the Key to the Vision



- non-food parts of food crops (wheat straw, corn stalks, etc.)
 - dedicated energy crops requiring low in-puts (e.g., perennial switchgrass)

“Carbon from plants not from dinosaurs”



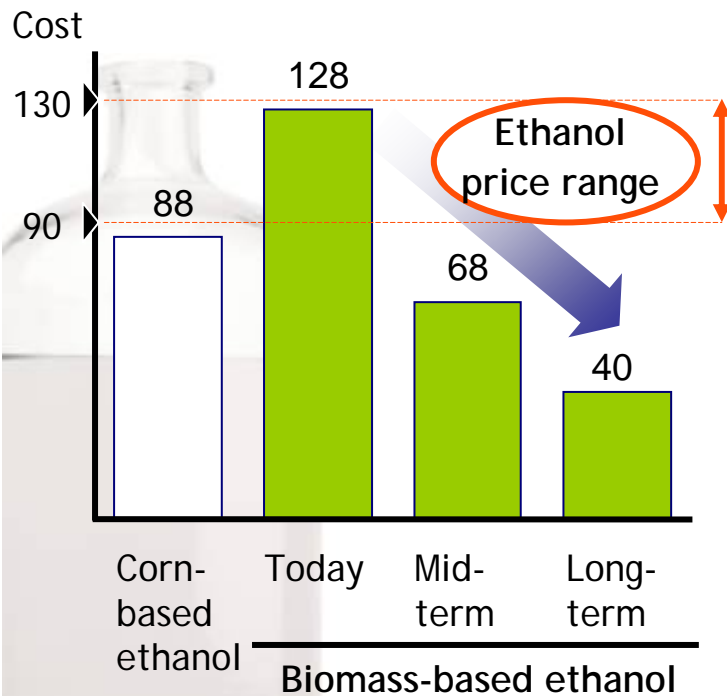
- Cellulose is a rigid crystalline carbohydrate and is the main component of plant cells
- Trichoderma produces a mixture of cellulase enzymes.
 - 2 cellobiohydrolases,
 - 8 endoglucanases,
 - 4 b-glucosidases.

Possible enzyme improvements:

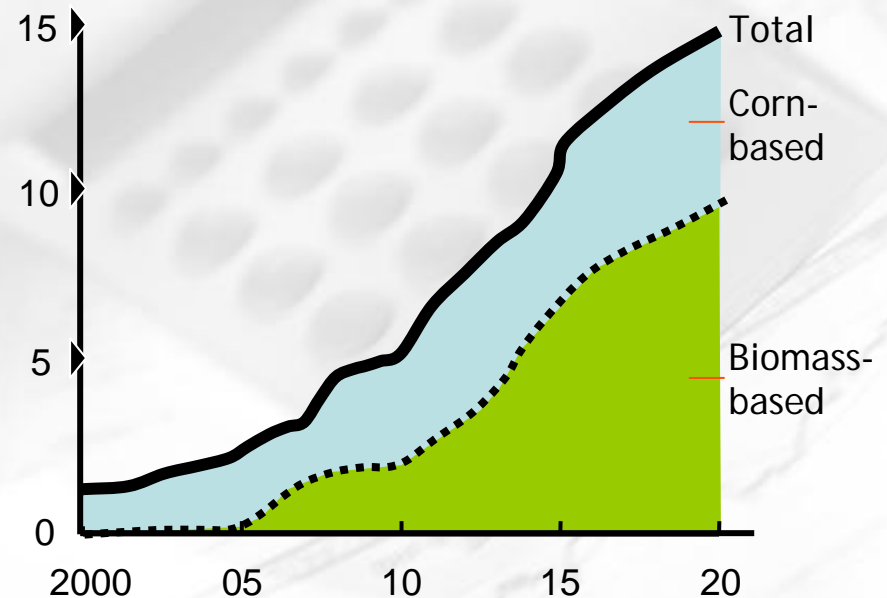
- Optimize the mixture
- Recruit from other species.
- Improve specific activity
- Reduced end-product inhibition

Bio-Ethanol: First Market to Profit From Biomass

Cost reduction
USD-Cent/gallon



US market growth (DoE estimate)
Billion gallons



Making Biofuels Affordable and Sustainable Throughout the World

- Invest in R&D and demonstration policies that create innovation and advancements needed for a large-scale, competitive biofuels industry
- Fund deployment policies that drive the development of the first billion gallons of cellulosic biofuels capacity at a price approaching that of gasoline and diesel
- Adopt a renewable fuels standard and flex-fuel vehicle requirement

- We envision a future where biotechnology fulfills many unmet needs (human health, fuels, chemicals & materials)
- We envision a future where biotechnology helps create sustainable industrial activities
- We envision a future where biorefineries take their place alongside oil refineries